



Repair and Disinfection of Water Mains

Every year waterborne disease outbreaks occur in the United States as a result of public water distribution system deficiencies. A significant number of these outbreaks are caused by broken water mains or contamination of water mains during construction or repair. Some experts estimate only 19 to 20 percent of waterborne disease outbreaks are reported and documented, and the problem may be much larger than we know. Disease outbreaks emphasize the importance of using proper procedures and methods when repairing water mains.

To prevent waterborne disease outbreaks, the Missouri Public Drinking Water Regulations 10 CSR 60-4.080(6) require every supplier of water to a public water system to disinfect all newly constructed or repaired water distribution mains, finished water storage facilities or wells by methods accepted by the Missouri Department of Natural Resources before being placed in or returned to service. Failure to use acceptable methods is a violation of the regulations that could result in enforcement action. The department only accepts the methods presented in the latest ANSI/AWWA Standard for Disinfecting Water Mains C651-05, which covers both the disinfection of new water mains and repairs of existing water mains. However, copies of the standard must be purchased. Consequently many operators do not have copies available for study and review. The following is a synopsis of the standard and covers some other practical issues of water main repair.

Many small water systems use backhoe or plumbing contractors to repair water mains and do not do the work themselves. Still, the water system officials are responsible for any work done in their water system even if it is done by a contractor. The chief operator of each system is in responsible charge and must oversee any repair work done to ensure the contractor uses the approved methods described below.

The first step is to locate the leak or repair area. Before starting, the area must be isolated to the fewest customers and the least number of water mains by locating and operating the appropriate main valves. Water pressure less than 20 pounds per square inch, or psi, is a health hazard because it can result in contamination of customer plumbing and the water mains. The larger the area affected, the higher the probability the water will be contaminated. Shutting off the well or water tower and putting the entire system out of water creates a health hazard for the entire community and is not a recommended practice even if a boil water notice is issued.

No amount of flushing, disinfecting or sampling of a main repair can make up for the unsanitary handling of materials or unsanitary practices during the repair. This starts with digging the repair trench. The trench must be dug on both sides of the main and be wide and long enough to accommodate a trench box and an access ladder. Trench boxes should be used when repairing leaks because the soil around the main is water soaked and unstable. Furthermore, most operators are not willing to slope trench walls at a 45° angle especially when digging in yards or the street. Ladders should always be used to safely get in and out of trenches to prevent slips and falls. These safety measures are required by the Occupational Safety and Health

Administration and aid in handling repair fittings in a sanitary manner. The repair trench must be sized to allow the operator to safely work on the problem area with enough room to clean the repair area and to handle the repair materials in a sanitary manner. The trench must be dug out below the main deep enough for the repair clamp or other fittings to be installed without getting them into trench water or soil.

Proper handling of trench water is essential to repairing a main break in a sanitary manner. Studies done on water main breaks have shown the trench water and soil are contaminated with total and Escherichia coliform and other bacteria. Therefore, it is essential the trench water be removed from the pipe area to be repaired and the repair clamp or other materials do not come into contact with the trench water or soil while it is being installed. This requires trenches be dug deep enough to keep the water adequately below the pipe and trench pumps are available to successfully control the trench water. It may be necessary to place gravel in the bottom of a trench to control the splashing of mud and water. If the capacity of a trench pump is inadequate, work should stop until additional or larger pumps are provided and the trench water is under control.

Repairing water mains requires flushing large amounts of water and disposing of strongly chlorinated water. If this water gets in a stream, river, lake, pond, or other waters of the state, it can cause fish kills and violations of the Missouri Clean Water Law that may result in enforcement action. In addition, strong chlorine solutions can kill vegetation and create very unhappy property owners. It is extremely important system operators know the destination of flushed water and have the means to dechlorinate flushed water. It is the responsibility of the system to ensure this water is disposed of properly.

Before a repair clamp is installed on a pipe, the pipe must be cleaned of any soil and washed using clean rags and a 1- to 5-percent bleach solution. When handling strong chlorine solutions, always follow appropriate safety practices to protect the operators. A several gallon plastic orchard sprayer filled with a bleach solution is the best way to provide an adequate amount of bleach for this purpose. Just before a repair clamp is installed on the pipe, the interior of both sides of the clamp must be cleaned and thoroughly sprayed with the bleach solution. Cleaning the repair clamp is easier if it is stored, hauled and handled in a sanitary manner before it is installed. Handling the clamp with clean hands or gloves and not setting it in dirt or mud is helpful. Also, preparing the clamp in a clean area as much as possible before taking it into the trench for installation is helpful. The same procedures must be followed when installing a tapping tee or saddle and include the tapping valve, pipe and other fittings installed and the tapping equipment.

The above procedures must be followed even if the main is repaired while it remains full of pressurized water and main pressures are kept above 20 psi. For systems that provide continuous disinfection and maintain adequate disinfection residuals in the distribution system, leaks repaired under pressure present little danger of contamination and may not require disinfection after the repair. However, if a system does not provide continuous disinfection or if the main is not repaired under pressure disinfection is required.

If a main has to be cut open to repair it, sufficient dirt must be removed to expose enough of each end of the pipe to adequately clean all areas that may come into contact with the repair fittings. The interior and exterior of each end must be cleaned of all soil and washed using clean rags and a 1- to 5-percent bleach solution. If a strong chlorine solution can be safely flushed from the affected area, calcium hypochlorite tablets should be placed in the ends of the pipe. Before doing so, all service lines in the affected area should be turned off to prevent strongly chlorinated water from entering customer plumbing. To keep tablets in place they should be stuck to the pipe using a food grade adhesive. The following table shows the number of tablets required to disinfect pipe.

Table 1 Number of 5 gram calcium hypochlorite tablets required for a dose of 25 mg/l.

Pipe Diameter	Length of Pipe in feet				
	13 ft. or less	18	20	30	40
Inches	Number of tablets				
4	1	1	1	1	1
6	1	1	1	2	2
8	1	2	2	3	4
10	2	3	3	4	5
12	3	4	4	6	7
16	4	6	7	10	13

The interior of the couplings, repair pipe and other fittings must be cleaned and washed with a bleach solution just before installation. Depending on the length of the repair pipe, a cloth swab soaked in bleach may be needed to clean and disinfect the interior of the pipe. Both exterior ends of the repair pipe must be cleaned and disinfected in the same manner as the water main ends. Care must be taken not to contaminate the couplings or repair pipe with soil or trench water during installation. The same procedures must be followed when replacing or installing a new valve elbow, hydrant, or flushing device.

After the repair is installed, the affected section of the main should be slowly filled with water to displace any air. If chlorine tablets were placed in the main it should be allowed to set several hours to allow the chlorine to dissolve and the repair to be disinfected. The amount of time required to disinfect the main depends upon the strength of the chlorine dosage. For example, if a 100 mg/l dose is used, the time required is three hours. Then ,the chlorinated water should be flushed from the main and properly handled. Provisions to remove the strong chlorine from the water may be necessary.

If chlorine tablets were not placed, the affected section of the main should be flushed at scouring velocities to remove any dirt or colored water and disinfected as described below. The following table shows the velocities that must be reached in water mains of different sizes to provide flushing velocities.

Table 2 Required flow of 2.5 ft./sec while maintaining a residual pressure of at least 20 psi.

Pipe Diameter	Flow in gallons per minute	Number of 2½ inch Hydrant Openings
2-inch	26 gpm	1
2½-inch	38 gpm	1
3-inch	60 gpm	1
4-inch	105 gpm	1
6-inch	225 gpm	1
8-inch	400 gpm	1
10-inch	600 gpm	1
12-inch	900 gpm	2
16-inch	1,600 gpm	2

After the repair is installed, the affected section of the main should be flushed and chlorinated in the same way as a new water main. The AWWA standard states this should be done where practical, but the department recommends always doing so. Furthermore, it is not impractical just because the system or its contractor does not have the necessary equipment or does not want to make the effort to chlorinate and flush. Three methods of chlorinating a main are presented but two of these methods, using calcium hypochlorite tablets or granules, work only if the main was cut open to repair it. This guide will focus on the third method, the continuous feed method.

To use the continuous feed method the system or its contractor must have the equipment necessary to feed a chlorine solution into the water main. The basic equipment needed is a solution tank to hold the chlorine solution and a pump to force the solution into the water main. The solution tank should be polyethylene with a tight fitting lid and valved fittings to connect the pump to the tank. The size of the tank depends on the amount of water line to be disinfected but tanks larger than 50 gallons are difficult to move by hand. The size of the pump also depends on the amount of line to be disinfected but for most repair jobs a pump that will do 5 gallons per minute should be more than adequate. If an electric pump is used, a portable power source must be available. The pump must include the hoses and fittings necessary to connect it to the solution tank and to the water main.

A valve should be provided on the discharge side of the pump to control the pump output. The volume of solution to disinfect a water main is small if it is injected directly into the water main as shown by the following table.

Table 3 Chlorine required to produce 25 mg/l concentration in 100 ft of pipe by diameter.

Pipe Diameter	1 % Chlorine solution
inches	gallons
4	0.16
6	0.36
8	0.65
10	1.02
12	1.44
16	2.60

However, if an existing service line is used to inject the chlorine into the main the entire volume of the service line must be displaced to get the chlorine to the main. One hundred feet of ¾-inch diameter pipe contains 2.77 gallons of water and 100 feet of 1-inch diameter pipe contains 4.04 gallons of water. If the solution is pumped through a fire hydrant the entire volume of the fire hydrant and its leg line must be displaced to get chlorine to the main. Ten feet of 6-inch diameter pipe contains 14.7 gallons of water. If a service line or hydrant is not available, a tap should be made to the water main near the isolating valve upstream of the line break.

Before starting the chlorination process, all service lines in the affected area should be turned off to prevent strongly chlorinated water from entering customer plumbing. After the chlorine source is connected to the water line, a hydrant or flushing device downstream of the main repair should be opened and the isolating valve upstream from the repair opened partially to provide a low flow of water through main. At the same time, pump chlorine solution into the main until at least a 25 mg/l residual is obtained at each hydrant or flushing device in the affected area. If there are multiple hydrants or flushing devices in the affected area they should be opened in succession until at least a 25 mg/l residual is obtained at each. After the desired chlorine residual is obtained, the hydrants or flushing devices is shut off and the isolating valve is shut off. After 24 hours the chlorine residual in the main should not be less than 10 mg/l. If it is, the chlorination process should be repeated.

Most water system operators do not want to wait 24 hours before restoring service to customers. Fortunately, the contact time required to disinfect a main can be reduced if the chlorine residual is increased. If the chlorine concentration is increased to 100 mg/l the contact time can be reduced to three hours. During the process the chlorine residual should not drop below 50 mg/l. If the dose is increased to 300 mg/l the contact time can be reduced to 15 minutes. However, methods must be provided to safely dispose of the very strongly chlorinated water.

After disinfection, the affected area must be flushed to remove any air, contamination or colored water and until chlorine residuals are less than 4 mg/l. Customer services can then be turned on and the main returned to service. Most customer homes are higher than the water mains, so if pressures were low in a main, they would have been even lower in the home's plumbing. Therefore, it is important each customer be notified a main repair involving possible low water pressures has occurred. This customer notice must advise each customer to flush all plumbing on their premises to remove any contamination, air, or colored water before using the water. It must also advise them to boil water for drinking or culinary purposes and ask them to notify the water system if they notice any color or odor other than chlorine in the water after flushing. The advisories can be hand delivered using doorknob hangers or door stuffers or can be distributed using electronic media.

The customer advisory should not be lifted until special water samples are collected upstream and downstream of the main repair and tested negative for coliform bacteria. If a large area of the system was affected more than two water samples may be required and the system should contact the appropriate department regional office for guidance. If any sample tests positive for coliform bacteria the customer advisory must continue and additional disinfection and flushing is required. System operators should contact the appropriate department regional office for guidance.

The Missouri Public Drinking Water Regulation 10 CSR 60-4.080(9) states that "Public water systems must maintain a minimum positive pressure of 20 psi throughout the distribution system under all normal operating conditions." The department concludes that water main leaks and repairs are normal operating conditions because of their frequent occurrence, because they are common to all water distribution systems and because locating leaks and repairing mains are routine duties for most water systems. Therefore, they are covered by the regulation. The Missouri Public Drinking Water Regulation 10 CSR 60-7.010(2) states "within 48 hours a supplier of water must report to the department any failure to comply with any drinking water regulation". This regulation is the legal basis for requiring water systems to report low pressure events to the department. A form, *Report of Low Water Pressure*, is available online at dnr.mo.gov/forms/780-2016-f.pdf, or from the department's regional offices. It can be filled out and faxed to the appropriate regional office. Doing so will fulfill the system's responsibility to report low pressure violations. The fax machines at each regional office operate 24 hours per day 7 days per week so the form can be faxed outside of normal business hours.

For More Information

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